

**IMPLEMENTATION OF PID CONTROLLER ON REVOLUTE CONTROL OF
UNIVERSAL STRETCH AND BENDING MACHINE (USBM) SIMPLIFIED
MODEL**

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This thesis is submitted as partial fulfillment of the requirements for the award of the
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DEDICATION

*Special dedicated to my family, my friends, my fellow colleague,
and to all faculty members*

For all your care, support, and believe in me

*Sincerely,
Norasyikin binti Julis.*

ACKNOWLEDGEMENT

Praise to Allah for His help and guidance that we finally able to complete this report on Implementation of Integral Control PID controller on Revolute Control of Universal Stretch and Bending Machine (USBM) Simplified Model.

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ABSTRAK

Tujuan utama projek ini adalah untuk mengawal kedudukan motor arus terus (*DC motor*) yang merupakan salah satu bahagian dalam *universal stretch and bending machine*. Oleh itu, Pengawal Perkadaran Terus, Kamiran Pembezaan (*Proportional Integral Derivatives Controller*). Langkah pertama dalam projek ini adalah untuk memperoleh model matematik (*Mathematical model*) untuk motor arus terus sebelum pengawal pengawal perkadaran terus, kamiran pembezaan boleh digunakan. Setelah itu, antara bahagian penting dalam projek ini adalah untuk mereka algorithm pengawal iaitu mencari nilai pemalar perkadaran terus, K_p , pemalar kamiran, K_i dan pemalar pembezaan, K_d menggunakan *root locus tuning method*. Simulasi untuk kawalan motor arus terus dibuat bertujuan untuk memahami sifat pengawal PID. Kemudian, pengawalan motor arus terus dihubungkan menggunakan Pengawal Logic Program Bolehubah (*Programmable Logic Controller, PLC*). Di dalam PLC, program *CX-Programmer* digunakan untuk melaksanakan pengawal menggunakan *ladder diagram*.

ABSTRACT

The aim of this project is to control DC motor position which is one component in USBM simplified model. Thus, the integral control, PID controller is used to control the position of the DC motor. Proportional-Integral Derivatives controller is widely used among the industries systems. At first stage of the project, the mathematical model of the plant, DC is derived before the PID controller is usable. The crucial part of designing the controller is tuning the three gains which are the Proportional gain, K_p , Integral gain, K_i , Derivatives gain, K_D are performed using Root-locus tuning method. The simulation of the DC motor position control is done in order to understand the PID controller. After that the controller and DC motor are interfaced using Programmable Logic Controller, PLC. Using PLC, the controller is algorithm is implemented by using ladder diagram in CX-programmer software

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LIST OF ABBREVIATION

<i>DC</i>	-	Direct current
<i>DM</i>	-	Data memory
<i>PB</i>	-	Push button
<i>PID</i>	-	Proportional Integral Derivatives Controller
<i>PIDAT</i>	-	Proportional Integral Derivatives Auto-tuning
<i>PLC</i>	-	Programmable logic controller
<i>USBM</i>	-	Universal Stretch and Bending Machine

LIST OF SYMBOLS

ζ	-	Damping ratio
π	-	Pi
θ	-	Angular displacement
$\%OS$	-	Percentage of Overshoot
ω_n	-	Natural frequency
$e(\infty)$	-	Steady State Error
B	-	Viscous Friction Coefficient
E_B	-	Induced voltage (V)
I_a	-	Armature current (A)
J_m	-	Equivalent moment inertia (kgm^2)
K_x	-	Torque constant (NmA^{-1})
K_b	-	Back emf constant (NmA^{-1})
$K_D K_3$	-	Derivatives gain
$K_i K_2$	-	Integral gain
$K_p K_1$	-	Proportional gain
K_v	-	Ratio of magnitude of compensator zero to compensator pole
R_x	-	Armature resistance (Ω)

T	-	Load torque (Nm)
T_e	-	Electromagnetic torque (Nm)
T_p	-	Peak time
T_s	-	Settling time
V_a	-	Armature Voltage (V)
x	-	Real part of operating point
y	-	Imaginary part of operating point
z_c	-	Compensator zero

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CHAPTER 1

INTRODUCTION

1.1 Background

This chapter discussed about the project overview. The chapter also explains the application, problem statement, objectives, and scope of the project.

1.2 Overview

The fact is DC motors continued to be a significant fraction of machinery purchased each year through the 1960s. The factor of DC motor continuity usage is; one was that DC power systems are still common in cars, trucks and aircraft. Thus, it is makes sense that the usage of DC power system wills the usage of DC motor. Another application of DC motor was a situation which variation of speed and position is needed. In terms of power electronics, even if there is no DC power supply that is available, solid-state rectifier and chopper circuit were used to create necessary DC power and DC motor were used to provided desired speed and position. But now, the other method of control in industry is using controller to control the DC power supply and varied the supply so output will give desired position or speed. Then, it is important to understand the concept of DC motor.

The DC motor is a rotating electric machine designed to operate from direct voltage source. The basic type is a permanent magnet DC motor where the stator of a permanent magnet DC motor is built from two or more permanent magnet pole pieces. The rotor is consisted of windings which are connected to a mechanical commutator. The basic concept of DC motor operation is when the opposite polarities of the energized winding and the stator magnet attract to each other; the rotor will rotate until it is aligned with the stator. By the time the rotor reaches alignment, the brushes move across the commutator contacts and energize the next winding.

As the aim is to control DC motor position, the PID controller could be purposed. Since in today's world, there are variety of controller exist, thus PID controller is one of its alternative. Over the decades, PID control technology has undergone many changes and today the controller may be the standard utility routine within the supervisory system software, a dedicated hardware process controller unit or an input-output module within a programmable electronic system which can be used for controlling system construction [1]. Even though industrial prove that for many control problems, especially those of the process industries, the Proportional, Integral and Derivatives (PID) controller is the main controller that being used. For these industrial problems, the PID control module is a building block that provides the regulation and disturbance rejection for single loop, cascade and multi-loop and multi-input multi-output control schemes [1].

PID controller is an important control tool for three reasons which are past record of success, wide availability and the most important factor is the simplicity in use. These reasons reinforce one another, thereby ensuring that the more general framework of digital control with higher order controllers has not really able to displace PID control [1]. But, when the process situation demands a more sophisticated controller or a more involved controller solution to control a complex process, then it required advance techniques. Even though where complexity of the process demands a multi-loop or multivariable control solution, a network based on PID control building blocks is often used.

Moreover, in this project it is important to understand the basic concept and application of universal stretch and bending machine. Thus, an article on USBM published by Lewa Attendorn gives a rough idea about the application of USBM in industry. Besides, there are several technical papers that related to this project. One of it is a paper on “A Sensorless Position Control System by Salient Pole Brushless DC Motor” by Nobuyuki Kasa and Hiroshi Watanabe. Besides, a paper on methods of tuning PID controller shows the alternative in tuning PID controller that written by Dong Hwa Kin titled Tuning PID controller Using Gain/ Phase Margin and Immune Algorithm.

1.3 Problem Statement

In this project PID controller is applied to control the position of the DC motor have been connected to potentiometer. As usual, using PID controller, the challenge is in tuning the parameters of the PID controller which are proportional gain, K_p , integral gain, K_i and derivatives gain, K_d . Then, the Programmable Logic Controller is used to interface the PID controller to control the DC motor. But, the Programmable Logic controller used supposes to offer analog as output.

1.4 Objectives

There are three objectives of this project that are to design a control system for revolute control of USBM using PID controller. Besides, the project also needs to simulate the suitable program, which is chosen based on controller used for the system. Lastly, the third objective is to interface the supervisory PLC that implement PID controller in controlling the DC motor of USBM.